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Research Article

Age-Related Changes of Lumbar Vertebral Body Morphometry

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Abstract

This study was designed to provide a large, accurate database of vertebral body size, focus¬ing on age-related changes along the lumbar spine, and to look for size variations with relation to sex. All lumbar vertebrae (L1-L5) of 212 individuals (0-90 years) were dissected and analyzed by age and sex. A digital caliper was used to measure all vertebral body heights, lengths, and widths. This study showed that the vertebral body size was independent of sex but correlated with the individuals' age. The most intensive growth of vertebral body sizes was found in children 1-7 year-old and the second peak of growth was observed in teenagers 13-16 year-old.

Anterior and posterior vertebral body heights were almost identical for all lumbar vertebrae in newborns and continuously increased through children, teenagers and adult age groups, then slightly decreased in senior persons due to osteopenia. The posterior vertebral body height was smaller than the anterior vertebral body height at L2 through L5 indicating posterior wedging with a peak at L3-L4 (except individuals of the 1st year of postnatal life). The superior vertebral body lengths constantly increased from L1 to L5 and inferior lengths - from L1 to L4, slightly decreased at L5. No significant difference was found between the superior and inferior vertebral body lengths of the same vertebra ($P > 0.05$). The superior vertebral body width typically was smaller than inferior widths of the same vertebra and superior width of adjacent inferior vertebra, resulting in a trapezoidal vertebral body shape in the lumbar spine.

As result of this research, a comprehensive database of vertebral body dimensions was generated from direct measurements of 1060 lumbar vertebrae. These results are invaluable in establishing an anthropometric model of the human lumbar spine, and provide useful data for spinal surgery and spinal implants design. In addition this information has important implications for workspace specifications for a robot-assisted surgery system.

Keywords: Vertebral body; Anatomical dimensions; Lumbar spine

Abbreviations

AVBH: Anterior Vertebral Body Height; PVBH: Posterior Vertebral Body Heights; SVBL: Superior Vertebral Body Length; IVBL: Inferior Vertebral Body Length; SVBW: Superior Vertebral Body Width; MVBW: Middle Vertebral Body Width; IVBW: Inferior Vertebral Body Width

Introduction

Existing databases of vertebral and inter vertebral dimensions are incomplete at present and limited either in accuracy, study population or parameters recorded. However, information on the precise dimensions of the lumbar vertebrae is essential for the spinal implants design, lumbar decompression surgery and workspace definition for robot-assisted surgery [1].

Previous studies have initiated the establishment of standard numeric values of vertebral body shape both in normal and pathological conditions [2-5]. The value of their data has depended on the number of samples and the accuracy of measurement. Many of the existing reports are based on a small sample size or isolated vertebrae of a small section of the spine. A comprehensive study of 12 specimens of human cadaveric lumbar vertebrae was published by Panjabi et al. however; the number of specimens was very limited as they were difficult to obtain [6]. Berry et al manually measured 30 skeletons, creating a database for implants but there was insufficient information to calculate lateral vertebral body sizes and not all pedicle dimensions were measured [7]. Fang et al. [8] reported an important study based upon CT scans of the lumbar spine obtained from Asian population, Aly and Amin [9] did research of lumbar spinal canal dimensions in Egyptians, but these are not necessarily applicable to Caucasians. The investigations of Zindrick et al. [10] and Chawla [11] were limited to the height, width, and transverse angles of vertebral pedicles. One large series was reported by Van Schaik et al. but they focused on the transverse process dimensions and structure only [12]. Gilad and Nissan measured the sagittal plane dimension of several anatomic structures of the vertebrae using lateral radiographs of 157 patients, and no data on L2 and L4 were provided [13]. Zhou et al published a large database of L3 - L5 vertebrae and L3/4 - L5/S1 inter vertebral disks characteristics from 126 digitized CT scans, unfortunately the investigation was limited by a small section of the spine [14]. The anatomic dimensions of lumbar vertebrae from CT scans of 55 patients were reported by Wolf et al, their study

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Table 1: Material of the research: number of complete lumbar spine specimens - age distribution.

Age Group	Year-old	N
1	0	23
2	0-1	12
3	1-3	9
4	3-7	7
5	8-12	6
6	13-16	8
7	17-20	14
8	21-35	33
9	36-60	38
10	60-74	36
11	75-90	26
Totally:		212

was designed for a robotic surgery workspace creation [1]. In the comprehensive investigation of 240 adult human skeletons from the Cleveland Museum of Natural History by Masharawi et al. T1 - L5 vertebral body dimensions were obtained, but no age-related data were indicated [15].

The investigations of Kunkel et al. established some prediction equations for human thoracic and lumbar vertebral morphometry [16]. The morphological changes of the vertebrae associated with normal aging are still subject of debate, whereas this knowledge is important in detecting vertebral fractures and degenerative shape changes [17-22]. Some studies of human spine indicated a decrease in vertebral heights with advancing age and menopause [23,24]. Many studies indicated that the numerical mathematical modeling of the human spine for biomechanical studies requires the establishment of an accurate and large database on vertebral morphometry [25-27].

In this investigation, using a well-controlled sample size and measuring devices, the authors sought to establish morphometry standards for all lumbar vertebrae for all age groups and found age-related changes in vertebral body shape and sizes.

Materials and Methods

Study population

Direct measurements of 7420 lumbar vertebral body dimensions by digital caliper were obtained from 212 normal complete lumbar spines (107 male, 105 female) of individuals (0 - 90 years). All anatomic samples of lumbar spine had been collected in 2001-2006 from cadavers of Caucasian individuals living in Lugansk city and region in Pathology Department of Lugansk Regional Hospital under a license of Bioethical Commission of LSMU (file №:3, 10-NOV-05), Ukraine. All specimens were originated from victims of trauma (without spine damage), poisonings, and asphyxia and sudden death form vascular disorders. The study material was distributed among 11 age groups: from newborns through senior people (Table 1).

Measuring methods

A total of 1060 vertebrae from L1 through L5 were measured. Direct measurements the following seven parameters were taken from each vertebral body, and their ratios were analyzed: anterior and posterior VB heights in the midsagittal plane; superior and inferior VB anteroposterior (A-P) lengths; superior, middle and inferior VB widths (Figure 1). Anterior (AVBH) and posterior (PVBH) vertebral body heights are distances in the sagittal plane between central borders of superior and inferior vertebral body, anteriorly and posteriorly, respectively.

Superior (SVBL) and inferior (IVBL) vertebral body lengths are distances in the sagittal plane between anterior and posterior borders of superior and inferior vertebral body, respectively.

Superior (SVBW), middle (MVBW) and inferior (IVBW) vertebral body widths are distances in the transverse plane between left and right borders of the superior, middle (1/2 of height), and inferior vertebral body, respectively. All measurements were taken from the external borders of the vertebral body rims, excluding any osteophytes.

Repeatability of measurements

To assess measurement errors for intra reliability tests, 4 patients were randomly selected and all parameters from their 20 lumbar vertebrae (L1-L5) were measured on 2 consecutive days by the same observer under similar experimental conditions. For inter reliability tests, two investigators undertook three sets of measurements from 20 third lumbar vertebrae.

Statistical analysis

Descriptive statistics were calculated for all measurements. Rate of a vertebral body growth was calculated as a % difference from a previous age group for all dimensions. The association of vertebral body dimensions with age was calculated using analysis of variance (ANOVA). Analysis of variance followed by orthogonal contrasts was used to compare the vertebral dimensions at different spinal levels. A significance level of $P < 0.05$ was used.

Results

Both the intra tester and inter tester reliability for all measurements were high. The intra class correlation coefficients varied from 0.93 to 0.97 for the intra tester reliability, and from 0.80 to 0.85 for the inter tester reliability. Validity was also very high ($r = 0.92$; $P < 0.001$).

Vertebral body heights and sagittal wedging

Table 2 summarizes data for the anterior and posterior vertebral body heights L1 - L5 for persons of different age groups. Anterior vertebral body heights were almost identical for all lumbar vertebrae

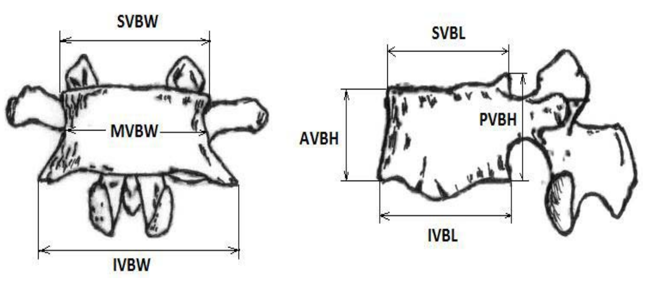

Figure 1: The measurement diagram: AVBH and PVBH - anterior and posterior body heights; SVBL and IVBL – superior and inferior vertebral body lengths; SVBW, MVBW and IVBW – superior, middle and inferior vertebral body widths, respectively.

Table 2: Vertical dimensions for lumbar vertebrae (mm) for 212 persons of different age groups (mean ± SD) (AVBH – anterior vertebral body height, PVBH – posterior vertebral body height).

Age group	Dimension	L1	L2	L3	L4	L5
(1) 0 yr	AVBH	6.9 ± 0.3	7.0 ± 0.2	7.2 ± 0.3	7.1 ± 0.3	7.0 ± 0.4
	PVBH	7.2 ± 0.6	7.2 ± 0.4	7.2 ± 0.4	7.3 ± 0.4	7.3 ± 0.3
(2) 0-1 yr	AVBH	8.4 ± 0.3	8.4 ± 0.2	8.5 ± 0.4	8.5 ± 0.4	8.4 ± 0.6
	PVBH	8.6 ± 0.7	8.6 ± 0.7	8.7 ± 0.7	8.7 ± 0.4	8.7 ± 0.9
(3) 1-3 yr	AVBH	11.7 ± 0.6	11.7 ± 0.8	12.1 ± 0.6	12.5 ± 1.0	12.5 ± 0.7
	PVBH	11.2 ± 0.5	11.1 ± 0.5	11.1 ± 0.7	11.3 ± 0.7	10.8 ± 0.6
(4) 3-7 yr	AVBH	16.1 ± 1.4	17.6 ± 2.2	18.5 ± 2.4	17.0 ± 1.7	16.7 ± 3.1
	PVBH	16.3 ± 0.9	15.9 ± 1.6	16.1 ± 1.8	14.7 ± 1.8	13.9 ± 1.3
(5) 8-12 yr	AVBH	18.9 ± 3.0	20.3 ± 4.7	23.0 ± 2.7	19.8 ± 3.4	20.3 ± 1.9
	PVBH	18.3 ± 3.6	19.9 ± 4.0	18.2 ± 3.4	16.5 ± 3.2	16.3 ± 3.2
(6) 13-16 yr	AVBH	23.6 ± 1.4	25.4 ± 2.7	28.2 ± 2.8	25.5 ± 1.8	25.3 ± 3.5
	PVBH	22.1 ± 2.4	25.3 ± 3.7	24.9 ± 3.2	23.5 ± 3.0	19.9 ± 3.3
(7) 17-20 yr	AVBH	25.2 ± 3.1	27.6 ± 2.6	29.0 ± 3.5	28.3 ± 2.1	27.9 ± 2.7
	PVBH	25.0 ± 3.8	27.1 ± 3.4	27.1 ± 2.7	26.5 ± 3.7	23.3 ± 3.4
(8) 21-35 yr	AVBH	25.5 ± 2.7	27.7 ± 2.5	30.8 ± 3.3	28.9 ± 4.6	28.2 ± 2.4
	PVBH	25.9 ± 3.1	27.1 ± 2.9	27.0 ± 2.9	25.8 ± 3.0	23.2 ± 2.9
(9) 36-60 yr	AVBH	24.5 ± 3.2	26.9 ± 2.8	29.3 ± 3.2	27.6 ± 2.7	28.0 ± 2.7
	PVBH	25.5 ± 3.4	26.6 ± 2.7	27.3 ± 2.8	25.9 ± 3.0	23.2 ± 2.8
(10) 60-74 yr	AVBH	23.8 ± 2.6	25.8 ± 3.2	28.4 ± 3.2	27.1 ± 2.8	26.8 ± 3.2
	PVBH	25.7 ± 3.3	25.9 ± 3.3	26.1 ± 2.7	25.1 ± 3.7	22.4 ± 3.1
(11) 75-90 yr	AVBH	21.7 ± 2.2	24.4 ± 2.9	27.2 ± 3.4	26.2 ± 3.2	26.1 ± 2.6
	PVBH	23.9 ± 2.2	24.2 ± 2.8	24.7 ± 2.2	24.6 ± 2.8	21.7 ± 2.5

in newborns (6.9 ± 0.3 mm - 7.2 ± 0.3 mm) and continuously increased through childhood, adolescence, and adulthood (in age group 8: 25.5 ± 2.7 mm for L1; 27.7 ± 2.5 mm for L2; 30.8 ± 3.3 mm for L3; 28.9 ± 4.6 mm for L4; 28.2 ± 2.4 mm for L5), then slightly decreased in senior persons due to osteopenia. Anterior vertebral body heights increased from L1 troughs L3 ($P < 0.05$) and decreased at L4 - L5 (for age groups 6 - 11). Figure 2 summarizes data for the anterior vertebral body heights L1 - L5 and rate of their growth for persons of different age groups. The most intensive rate of growth of anterior vertebral body heights (above of 40%) was found in children 3rd and 4th age groups (1-7 year-old) and the second peak of growth was observed in teenagers 13-16 year-old (age group 6). ANOVA shows a statistically significant correlation between the anterior vertebral body heights and person's age (r=0.57 in men and r=0.69 in women; $P < 0.0001$).

Average sizes of posterior vertebral body heights for L1 - L5 in newborns and infants of the first year of postnatal life were slightly above than anterior heights (7.2 - 7.3 mm and 8.6 - 8.7 mm, respectively). But starting from the 3rd age group on, the situation is quit opposite, anterior heights prevailed ($P < 0.05$).

Posterior vertebral body heights continuously increased with the age and reach their maximums in adults (25.9 ± 3.1 mm for L1, 27.1 ± 2.9 mm for L2, 27.0 ± 2.9 mm for L3, 25.8 ± 3.0 mm for L4 and 23.2 ± 2.9 mm for L5). The correlation of this dimension with the age was also significant for both sexes (r=0.66 in men and r=0.64 in women ($P < 0.0001$). The posterior vertebral body height was smaller than the anterior vertebral body height at L2 through L5 indicating

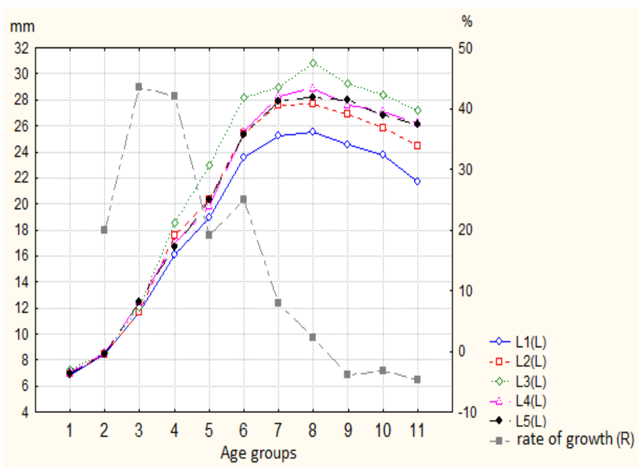

Figure 2: Anterior vertebral body heights (mm) for different age groups and rate of growth (%).

posterior wedging with a peak at L3 - L4 (except persons of the 1st year of postnatal life).

Vertebral body lengths

The superior vertebral body lengths were 7.6 ± 0.5 mm - 7.8 ± 0.3 mm in newborns (L1-L5) and drastically increased during the first 3 years of the postnatal life (age groups 1-3), reaching 17.2 ± 0.7 mm - 17.7 ± 0.6 mm (Table 3). Unlike vertical dimensions, that is the only peak of growth for vertebral body lengths with more than

Table 3: Longitudinal dimensions for lumbar vertebrae (mm) for 212 persons of different age groups (mean ± SD) (SVBL – superior vertebral body length, IVBL - inferior vertebral body length).

Age group	Dimension	L1	L2	L3	L4	L5
(1) 0 yr	SVBL	7.6 ± 0.5	7.6 ± 0.4	7.7 ± 0.4	7.8 ± 0.2	7.8 ± 0.3
	IVBL	7.7 ± 0.3	7.7 ± 0.3	7.7 ± 0.4	7.8 ± 0.4	7.8 ± 0.4
(2) 0-1 yr	SVBL	9.4 ± 0.7	9.5 ± 0.5	9.5 ± 0.7	9.6 ± 0.7	9.6 ± 0.7
	IVBL	9.4 ± 0.5	9.6 ± 0.8	9.5 ± 0.7	9.6 ± 0.7	9.6 ± 0.7
(3) 1-3 yr	SVBL	17.4 ± 0.5	17.2 ± 0.7	17.5 ± 0.7	17.7 ± 0.6	17.2 ± 0.8
	IVBL	16.3 ± 1.2	16.3 ± 1.2	16.2 ± 1.3	16.2 ± 1.6	16.3 ± 1.2
(4) 3-7 yr	SVBL	20.9 ± 2.4	22.0 ± 3.1	22.9 ± 2.8	23.2 ± 3.2	24.9 ± 3.1
	IVBL	22.6 ± 3.5	23.2 ± 2.6	24.5 ± 3.3	24.7 ± 2.9	23.1 ± 1.4
(5) 8-12 yr	SVBL	24.6 ± 5.1	26.0 ± 5.6	28.8 ± 7.6	28.8 ± 6.2	28.3 ± 6.1
	IVBL	25.6 ± 5.9	28.5 ± 6.4	27.4 ± 5.5	28.0 ± 5.4	26.5 ± 3.6
(6) 13-16 yr	SVBL	27.3 ± 1.8	27.3 ± 3.9	29.7 ± 3.0	30.3 ± 2.9	31.9 ± 4.4
	IVBL	29.1 ± 2.6	30.7 ± 2.6	31.1 ± 2.6	32.7 ± 2.1	30.6 ± 2.4
(7) 17-20 yr	SVBL	30.1 ± 2.7	33.0 ± 3.2	34.5 ± 4.1	34.6 ± 2.5	34.6 ± 2.6
	IVBL	31.3 ± 2.9	34.7 ± 2.8	35.1 ± 3.7	35.2 ± 2.3	33.1 ± 2.8
(8) 21-35 yr	SVBL	31.2 ± 4.2	33.2 ± 3.6	34.9 ± 4.2	34.3 ± 4.2	35.5 ± 5.0
	IVBL	32.9 ± 4.0	33.9 ± 3.5	34.5 ± 3.7	36.0 ± 3.9	33.6 ± 5.3
(9) 36-60 yr	SVBL	32.4 ± 4.3	34.1 ± 4.5	35.6 ± 4.0	35.2 ± 4.3	36.8 ± 4.5
	IVBL	32.5 ± 4.8	34.6 ± 4.7	35.5 ± 5.3	36.1 ± 4.7	34.7 ± 5.7
(10) 60-74 yr	SVBL	32.5 ± 4.5	34.3 ± 4.7	36.1 ± 4.6	36.4 ± 4.8	37.0 ± 4.8
	IVBL	34.1 ± 4.2	35.6 ± 4.5	36.7 ± 4.9	37.3 ± 4.9	35.4 ± 5.7
(11) 75-90 yr	SVBL	33.5 ± 3.7	34.8 ± 3.6	37.0 ± 3.8	36.7 ± 4.0	36.4 ± 4.2
	IVBL	34.2 ± 4.2	35.8 ± 3.7	36.4 ± 4.8	37.5 ± 3.2	34.9 ± 4.7

80% rate (Figure 3). Even later, when the rate of growth is much less, this dimension was growing up until adulthood. The superior vertebral body lengths constantly increased from L1 (32.4 ± 4.3 mm) to L5 (37.0 ± 4.8 mm) in the lumbar spine (age group 10). The inferior vertebral body length increased from L1 (34.1 ± 4.2 mm) to L4 (37.3 ± 4.9 mm) and then slightly decreased at L5 (34.7 ± 5.7 mm). No significant difference was found between the superior and inferior vertebral body lengths of the same vertebra (P >0.05). ANOVA shows a statistically significant correlation between the superior vertebral body lengths and person's age r=0.76 for men and r=0.71 for women (P <0.0001).

Vertebral body widths

Table 4 summarizes data for the superior, middle and inferior vertebral body widths L1 - L5 for persons of different age groups. The superior vertebral body widths slightly increased from L1 to L5 in newborns (14.5 ± 0.9 mm - 14.8 ± 0.6 mm) and infants of the first year of postnatal life (17.3 ± 1.4 mm - 17.6 ± 1.6 mm). The middle vertebral body width was bigger than superior and inferior one in the first two age groups (P < 0.01) and was in the range 15.1 ± 0.6 mm - 15.4 ± 0.6 mm in newborns and 17.6 ± 1.2 mm - 18.0 ± 1.3 mm in 1st year infants. The most intensive vertebral body growth in coronal plane (more then 60%) was registered in the first three years of the postnatal life (age group 3) (Figure 4). The second peak of growth (up to 30%) was found in teenagers (age group 6) and in this age middle vertebral body width became the same size or slightly below than the superior and inferior one and vertebral "waist" formation began. In adults (e.g. age group 10), superior vertebral body widths constantly increased from L1 to L5 (49.3 ± 7.0 mm - 56.0 ± 7.5 mm). The superior vertebral body width typically was smaller than inferior widths of the same vertebra and superior width of adjacent inferior vertebra, resulting in a trapezoidal vertebral body shape in the lumbar spine. Also with age, the vertebral "waist" (middle width) became less thick compared with superior and inferior widths at the same vertebrae. ANOVA shows a statistically significant correlation between vertebral body widths and age (r=0.78 for men and r=0.72 for women; P < 0.0001).

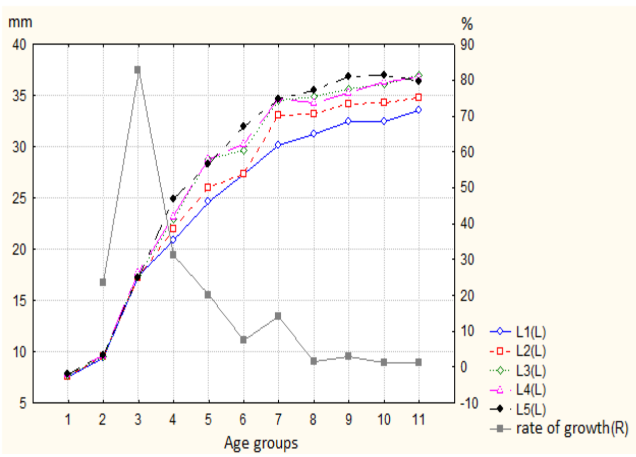

Figure 3: Superior vertebral body lengths (mm) for different age groups and rate of growth (%).

Table 4: Widths dimensions for lumbar vertebrae (mm) for 212 persons of different age groups (mean ± SD) (SVBW – superior vertebral body width, MVBW - middle vertebral body width, IVBW - inferior vertebral body width).

Age group	Dimension	L1	L2	L3	L4	L5
(1) 0 yr	SVBW	14.5 ± 0.9	14.6 ± 0.8	14.6 ± 0.6	14.8 ± 0.5	14.8 ± 0.6
	MVBW	15.1 ± 0.6	15.1 ± 0.6	15.2 ± 0.7	15.4 ± 0.6	15.4 ± 0.6
	IVBW	14.7 ± 0.5	14.6 ± 0.6	14.6 ± 0.7	14.9 ± 0.7	14.9 ± 0.7
(2) 0-1 yr	SVBW	17.3 ± 1.4	17.3 ± 0.9	17.4 ± 1.3	17.5 ± 1.2	17.6 ± 1.6
	MVBW	17.6 ± 1.2	17.8 ± 1.1	17.8 ± 1.3	17.9 ± 1.2	18.0 ± 1.3
	IVBW	17.2 ± 1.0	17.6 ± 1.5	17.4 ± 1.3	17.6 ± 1.2	17.7 ± 1.3
(3) 1-3 yr	SVBW	28.9 ± 0.9	28.7 ± 1.1	29.2 ± 1.2	29.5 ± 1.1	28.6 ± 1.3
	MVBW	27.6 ± 1.1	27.4 ± 1.5	27.6 ± 1.5	27.7 ± 1.7	27.4 ± 1.5
	IVBW	27.2 ± 1.9	27.2 ± 2.1	27.0 ± 2.1	26.9 ± 2.7	27.1 ± 2.1
(4) 3-7 yr	SVBW	31.4 ± 3.6	33.0 ± 4.6	34.4 ± 4.3	34.8 ± 4.8	36.5 ± 5.8
	MVBW	32.2 ± 4.2	33.4 ± 4.2	35.1 ± 4.5	35.4 ± 4.5	34.8 ± 5.2
	IVBW	33.9 ± 5.2	34.9 ± 3.9	36.8 ± 4.9	37.1 ± 4.3	34.0 ± 5.1
(5) 8-12 yr	SVBW	32.8 ± 6.7	34.7 ± 7.5	38.4 ± 10.1	38.4 ± 8.3	37.8 ± 8.1
	MVBW	32.5 ± 7.1	35.5 ± 7.8	36.6 ± 8.1	37.0 ± 7.3	35.7 ± 6.3
	IVBW	34.1 ± 7.9	38.0 ± 8.5	36.5 ± 7.4	37.3 ± 7.2	35.3 ± 4.8
(6) 13-16 yr	SVBW	41.0 ± 2.7	40.9 ± 5.8	44.6 ± 4.5	45.5 ± 4.4	47.8 ± 6.7
	MVBW	41.1 ± 2.8	42.3 ± 3.4	44.4 ± 3.5	46.1 ± 3.3	45.6 ± 3.8
	IVBW	43.7 ± 3.9	46.1 ± 3.9	46.7 ± 3.9	49.0 ± 3.2	45.9 ± 3.7
(7) 17-20 yr	SVBW	43.6 ± 3.9	47.8 ± 4.5	50.1 ± 5.9	50.1 ± 3.5	50.2 ± 3.9
	MVBW	42.7 ± 3.6	47.3 ± 4.0	48.7 ± 5.1	48.8 ± 3.2	47.3 ± 3.6
	IVBW	45.3 ± 4.3	50.3 ± 4.0	50.9 ± 5.3	51.1 ± 3.2	48.0 ± 4.2
(8) 21-35 yr	SVBW	46.9 ± 6.4	49.8 ± 5.4	52.4 ± 6.4	51.5 ± 6.2	53.3 ± 7.5
	MVBW	46.1 ± 5.8	48.3 ± 4.9	50.1 ± 5.6	50.7 ± 5.7	49.8 ± 7.2
	IVBW	49.3 ± 6.0	50.8 ± 5.3	51.8 ± 5.5	54.0 ± 5.8	50.4 ± 8.0
(9) 36-60 yr	SVBW	48.6 ± 6.4	51.2 ± 6.7	53.3 ± 6.1	52.8 ± 6.4	55.2 ± 6.8
	MVBW	46.2 ± 6.2	49.1 ± 6.4	50.8 ± 6.7	50.9 ± 6.4	51.1 ± 7.0
	IVBW	48.8 ± 7.2	51.9 ± 7.0	53.2 ± 8.0	54.1 ± 7.1	52.1 ± 8.6
(10) 60-74 yr	SVBW	49.3 ± 7.0	52.0 ± 7.3	54.6 ± 7.2	55.1 ± 7.4	56.0 ± 7.5
	MVBW	47.4 ± 6.7	50.0 ± 6.7	52.1 ± 7.0	52.8 ± 7.1	51.8 ± 7.8
	IVBW	51.6 ± 6.7	53.9 ± 7.0	55.6 ± 7.6	56.4 ± 7.5	53.6 ± 8.9
(11) 75-90 yr	SVBW	50.2 ± 5.5	52.2 ± 5.4	55.5 ± 5.7	55.1 ± 6.0	54.7 ± 6.2
	MVBW	47.3 ± 5.4	49.4 ± 4.7	51.5 ± 5.5	52.2 ± 4.5	50.0 ± 6.0
	IVBW	51.4 ± 6.2	53.7 ± 5.5	54.6 ± 7.1	56.3 ± 4.8	52.4 ± 7.1

Discussion

Information regarding the precise dimensions of the lumbar vertebral bodies is essential for spinal surgery and instrumentation, but we did not find longitudinal studies covering all age groups because of the extreme difficulty in obtaining such specimens. Even in the most comprehensive investigations like Masharawi et al., where dimensions were obtained from 240 normal complete spines of adult human skeletons (age range 20 - 80 years), or Wolf et al. (20 - 90 years old 55 patients), it is assumed that the vertebral body external shape is maintained with age [1,15]. Our finding challenges this concept and shows that a vertebral body is a dynamic structure, which grows constantly with different velocities until maturation. Shape of vertebral body is also different for different age groups. In newborns and infants of the first year of the postnatal life, L1-L5 vertebral bodies are oval in shape and almost identical in size. They grow dramatically in childhood and become cylindrical in shape. We have registered 2 peaks of vertebral body grow: in children of 1-3 years old and teenagers 13-16 years old. In 17-20 years old individuals, lumbar vertebral bodies get a definite shape (middle vertebral body width is less than superior or inferior one).

Measurements of vertebral body heights indicated a most rapid growth of anterior vertebral body height in L3 (compare with other lumbar vertebrae), one of the factors, as we believe, that contributes to the lumbar curve formation. Also our results shows decrease in

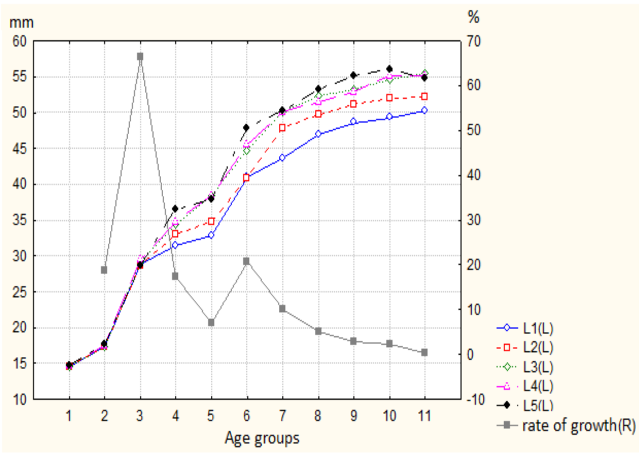

Figure 4: Superior vertebral body widths (mm) for different age groups and rate of growth (%).

vertebral heights with advancing age and menopause that supports some earlier studies [13,28,29] and challenges another opinion that decreases in human height with aging, results from a decrease in the thickness of the inter vertebral discs only [15,30].

The current data indicate that vertebral body lengths and widths constantly increase with the age. There are the same two peaks of growth in kids and teenagers groups. Also, vertebral body lengths and widths rates of growth are different in L1 - L5 row: L1 growths the less intensively and L5 - the most (Figure 4). This finding supports the prevalent concept about pyramidal structure of the vertebral column, in which the vertebral body dimensions continuously increase along the lumbar spine [14,31].

Our results show a statistically significant correlation between all vertebral body dimensions and age for both, men and women. This is in contrast with earlier studies that did not find such a correlation [15]. The contrasting findings are possibly due to the larger sample size and the age groups used in the current study (age range 0-90 years vs. 20-80 years). In addition, our results support the opinion that there is no sexual dimorphism ($P > 0.05$) in measurements of lumbar vertebral bodies [32,33].

Knowing the exact vertebral body size and shape is an important factor in the diagnostic and treatment processes of different spinal deformities. This study has been conducted to evaluate lumbar vertebral body anatomy of the Eastern Ukrainian population in terms of morphometry measurements in healthy cases as well as giving data to the spinal surgeons for more precise operations planning, choosing an adequate inter body device or appropriate bone graft, and fixation plates or screws to the different vertebral levels. Further studies are needed with larger samples in order to support our data and biomechanical studies are required to validate these implications.

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